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HFDA-03B Splice Test Production Report

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1.0 INTRODUCTION

The goal of HFDA-03B was to test the splice joints in a configuration similar to that of in a magnet. Note that the splicing technology has been already checked using superconducting transformer tests. Additionally HFDA-03B would allow us to test if the conductor could carry currents above 20 kA under conditions similar to that of in a magnet. Detailed magnetic and mechanical analysis of HFDA-03B has been reported in TD-03-031.

2.0 MODIFICATIONS TO THE COIL ASSEMBLY

The fabrication procedure followed was very similar to that of HFDA-03A¹. The same half coil was used with some modifications to test the mid-plane cable along with the splice joints. The return end shunts on both inner and outer layers of the coil were carefully removed and new NbTi lead cables were spliced. Fig. 1 shows the new splice joints. The cable next to the splice joints was cut to separate the mid-plane cable from the rest of the turns. This configuration would allow us to test the four splices (LE inner, LE outer, RE inner and RE outer) in series or two splice joints in the inner or outer layer separately. Fig. 2 shows the schematic of the layout.

¹ HFDA-03A Production Report: TD-03-001

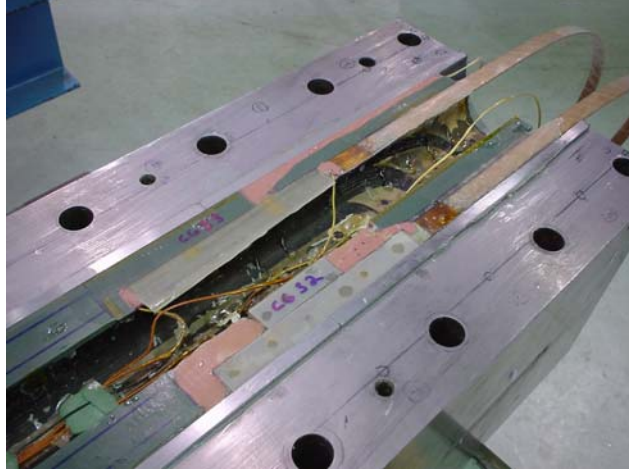


Fig. 1: *Return end splice joints.*

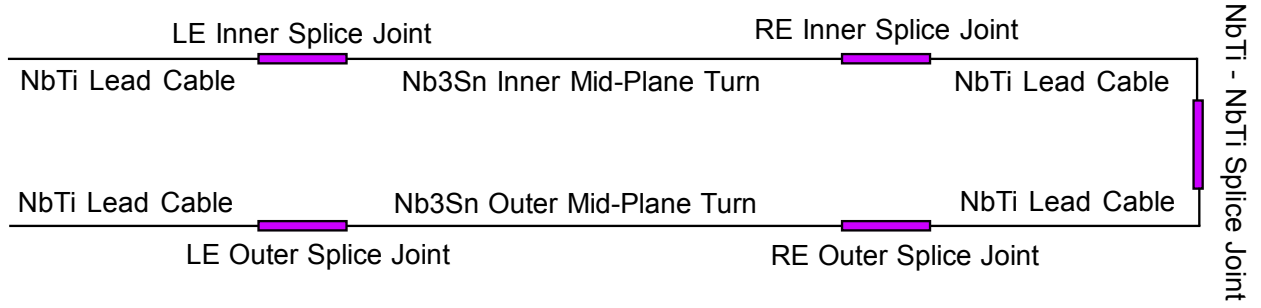


Fig. 2: *Schematic of the splice joint set up. By disconnecting NbTi – NbTi splice joint in the return end, we could test two splice joints in the inner or outer splice joints separately.*

3.0 INSTRUMENTATION

Capacitance gauges were installed for the first time in the mid-plane. A capacitance gauge on each layer was placed near the return end splice joint as we decided not to peel the G10 shim in the other areas. The gauges were calibrated both at room temperature and at 4.2 K. Two aluminum bronze spacers, one near the LE and one in the straight section were instrumented with resistive strain gauges to measure azimuthal stress. The initial zero readings were taken both at room temperature and at 4.2 K.

All the instrumentation that was on the coil for HFDA-03A test was retained. We replaced a broken temperature sensor near the return end splice joint. Fig. 3 shows the schematic of the instrumentation layout in the coil.

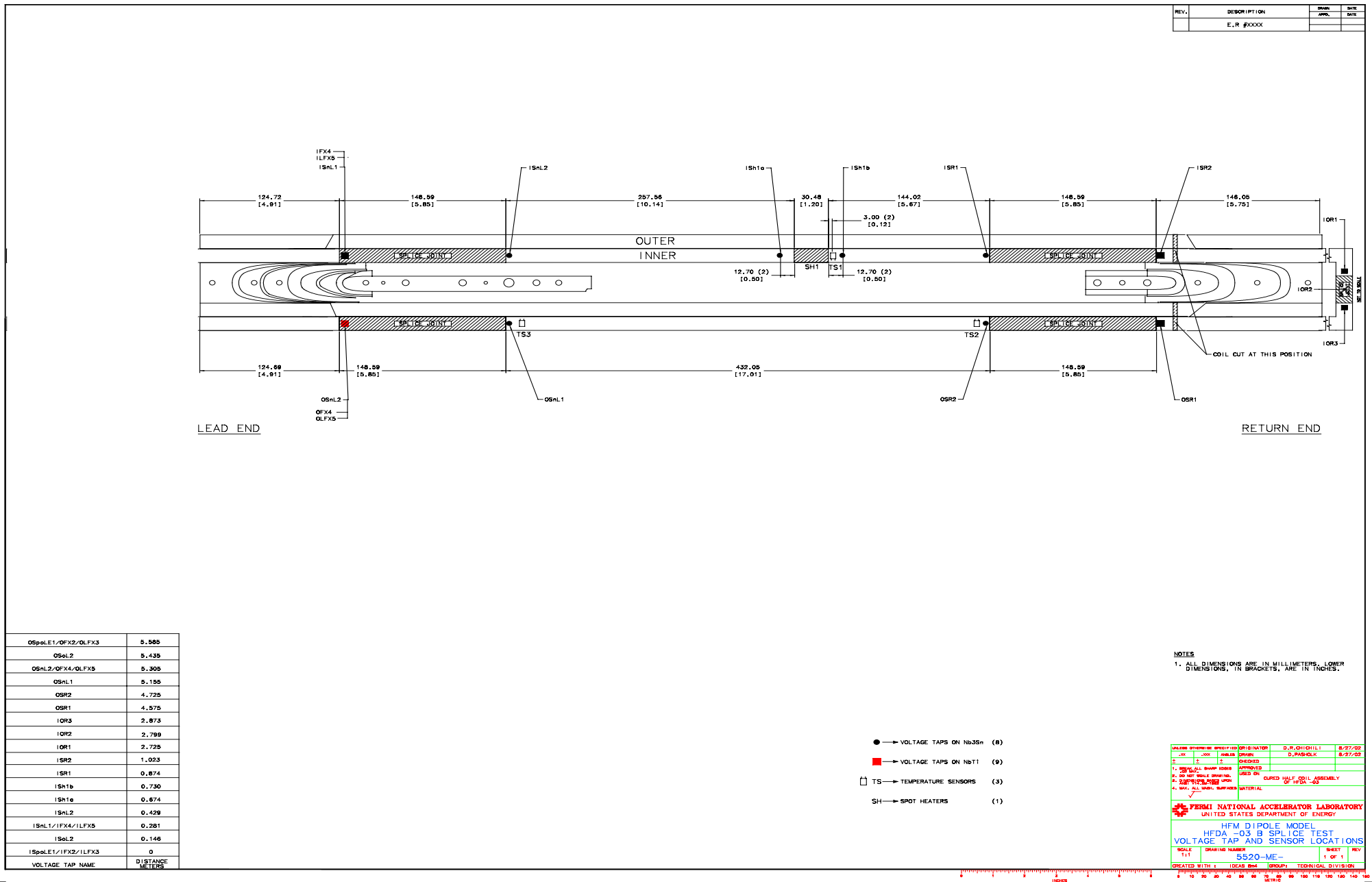


Fig. 3: Instrumentation layout for HFDA-03B

4.0 MAGNET ASSEMBLY

Two Kapton layers totaling 50 μm were placed on the radial surface of the half coil to create interference between the coil surface and the spacer. Kapton layers were also placed on the outer surface of the iron mirror such that there is a clearance of 75 μm between the spacer inner radius and the mirror outer radius. Note that the nominal ground insulation thickness on the iron mirror is 0.5 mm. The coil assembly along with the iron mirror and aluminum spacers was placed in the yoke. The layout of the iron yoke and stainless steel laminations with respect to the coil is similar to that of HFDA-03A. There are 8 stainless steel laminations in the LE, 24 iron yoke in the straight section and 8 and half stainless steel laminations in RE per half magnet. Note that each lamination is 25 mm thick. During yoking/clamping the gauge readings were monitored and Figs. 4 and 5 show the azimuthal stress in the coil mid-plane and in the spacers respectively.

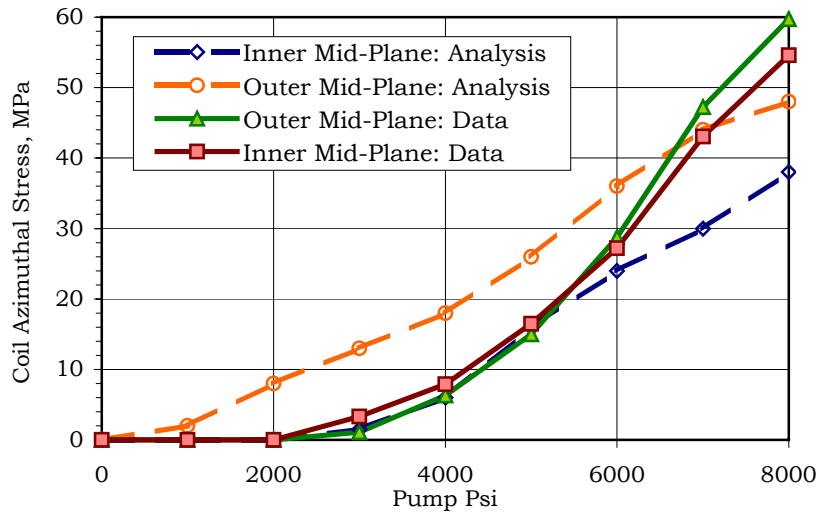


Fig. 4: Evolution of stress in the coil during yoking/clamping.

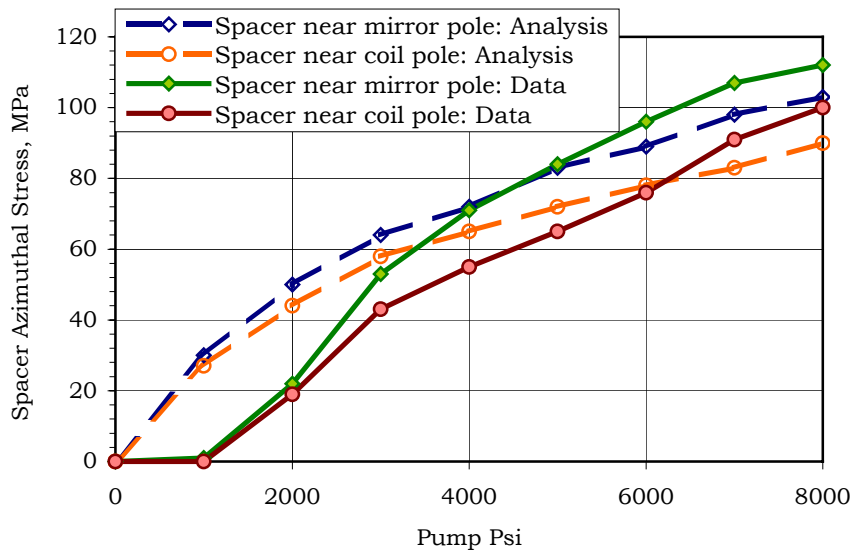


Fig. 5: Evolution of stress in the spacer during yoking/clamping.

At 8000 Pump Psi, the clamps were inserted using a separate set of pusher blocks. Two clamps one on each side were inserted simultaneously starting from the middle of the magnet. The coil resistance was monitored during the yoking/clamping operation to detect any possible coil to ground or heater to ground shorts. Table 1 shows the data along with ANSYS calculations. After spring back, the azimuthal stress in the coil is about 27 MPa in the inner layer and 24 MPa in the outer layer compared to 22 MPa and 35 MPa predicted by analysis. Fig. 6 shows the yoked coil assembly.

	Inner Midplane		Outer Midplane		Spacer: Coil Side		Spacer: Mirror Side		Spacer: Midplane	
	Data	Ansys	Data	Ansys	Data	Ansys	Data	Ansys	Data	Ansys
Yoking /Clamping	54.6	40	59.7	50	100	90	112	103	65	70
After Spring Back	27.1	22	23.9	35	49	80	65	72	53	50
After Skinning	17.7	32	50.8	40	60	90	70	75	54	65

Table 1: Azimuthal stress (MPa) in coil and spacer during various stages of assembly.

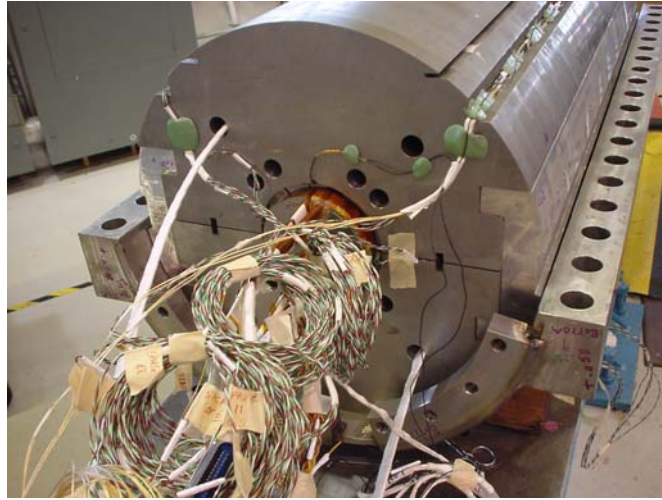


Fig. 6: Yoked/clamped coil assembly

Skin halves were placed around the yoked assembly and bolts were tightened. The stress in the coil and in the spacers was monitored throughout the bolting process. The final stress values are given in Table 1. The data matches reasonably well with ANSYS computations except for the inner layer after skinning. The data indicates that the pre-stress in the coil decreases after skinning whereas the computations show that it increases. Considering that the stiffness of both inner and outer layers is same and the rest of the data indicates that the stress should increase, we should discard the measured inner-layer data after skinning. To get more precise measurements beam gauges will be inserted in the mid-plane for future magnets.

Before tightening the bolts, NbTi lead cables from return end were routed to lead end through the slot, which was used for skin welding alignment key (see Fig. 7). G10 filler pieces along with epoxy

were used to secure the lead cable around the bend. The NbTi-NbTi splice joint was actually made in the lead end side so that it will easier to remove for the second thermal cycle.

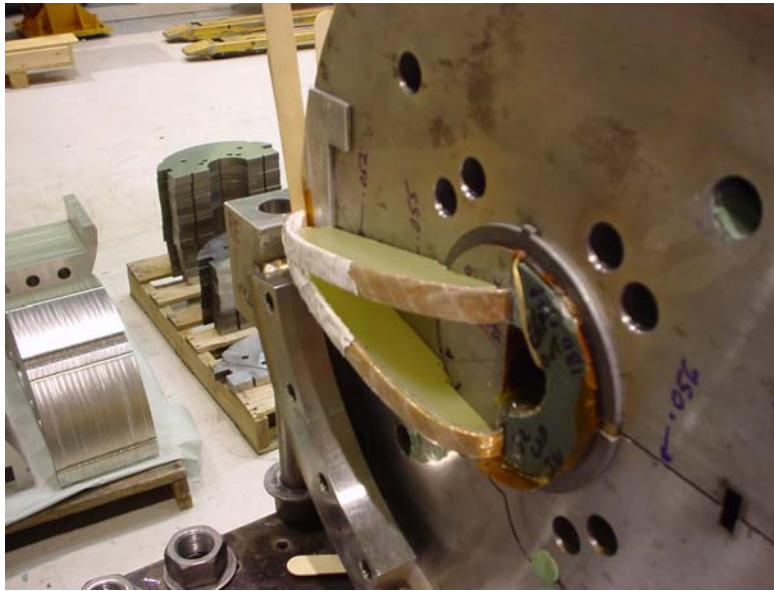


Fig. 7: RE lead cable routing.

The lead cables were routed through the standoff plate and secured. All wires were terminated to the hypertronic connectors as per the specifications from VMTF.